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ABSTRACT

The Method for Analyzing Content Sequence (MACS), based on the Posner-Strike categorization scheme for classifying content sequencing principles, enables a curriculum researcher or evaluator to describe in quantitative terms how the content in any given curriculum guide or textbook is sequenced. Using MACS, a curriculum worker can determine both kinds of sequencing principles which a textbook or curriculum guide employs and how extensive is the vertical structuring of content. Discrepancies between analyst-produced profiles of eleven community college textbooks, and those created by subject specialists were measured in order to test the reliability of the procedure. They were then studied in terms of program variables, analyst variables, and analyst-program variables in order to evaluate MACS and to provide guidelines for its use. (BW)

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# The Development and Validation of A Method for Analyzing Content Sequence (MACS)

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# The Development and Validation of A Method for Analyzing Content Sequence (MACS)[1]

Although content sequence is acknowledged to be an important area of educational theory (Bruner, 1966; Johnson, 1967) and research (Briggs, 1968; Heimer, 1969), the three most thorough reviews of the literature (Briggs, 1968; Heimer, 1969; Tennyson, 1972) reveal a paucity of definitive studies. This deficiency in the research may be attributable in part to a failure "to describe, let alone to measure, how the programs in 'experimental' and 'control' situations actually differ from one another -- or even to certify that they do." (Charters and Jones, 1973, p. 5) This potential lack of "construct validity" among treatments (Posner, 1973) may, in fact, result in the researcher comparing "non-events" rather than "events" (Charters and Jones, 1973).

The present study was intended to develop and validate a procedure by which a curriculum researcher or evaluator could describe in quantitative terms how the content in any given curriculum guide or textbook is sequenced. With this procedure, a curriculum worker could determine both the kinds of sequencing principle which a textbook/curriculum guide employs and how extensive the vertical structuring of content is (see Posner, 1974).

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Since the procedure is based on a categorization scheme for classifying content sequencing principles (Posner and Strike, 1975), it is recommended that the reader first study the scheme before attempting to understand the procedure. A brief summary of the categorization scheme is presented in Appendix A.

Development of MACS

The Method for Analyzing Content Sequence (Appendix B) grew out of an attempt to reality test the categorization scheme previously described in Appendix A. The authors attempted to determine whether the categories of sequencing principles adequately cover the range of sequencing principles employed in community college curricula.

In order to carry out this reality test, a broad range of community college curricula were selected (see Appendix C) and an analysis of each one was attempted. Immediately upon attempting the analysis, problems emerged. First was the problem of how to display the analysis. Second was the problem of analyst subjectivity and analysis validity. An attempt at solving these problems resulted in an attempt at developing and validating a Method for Analyzing Content Sequence (MACS) based on the categorization scheme.

Before one can begin any analysis of ordering relationships between content elements, one first has to decide on what content elements he is going to focus his study. These elements range in level from a macro-level (e.g., courses) to a more micro-level (e.g., topics within courses) (see Posner, 1974). What one means by a content element drastically affects what ordering relations he sees. In order to operationalize the concept of content elements, a definition

of this concept was stipulated for the purpose of the present study. A micro-level content element was defined as any chapter in a textbook or unit in a curriculum guide. A macro-level content element was defined as the largest sub-category of content in a textbook/curriculum guide. Thus, a textbook may have its chapters grouped into "parts," and a curriculum guide may have its units grouped into courses. When such a situation occurs, there is a clear distinction between micro- and macro-levels. When such is not the case, there was considered to be but one level, labeled the macro-level (for the purpose of this study).

A preliminary set of procedural steps were outlined and a "content elements-sequencing principles matrix" was designed. These two items along with an explication of the Posner-Strike categorization scheme were given to 20 graduate students studying curriculum. They were each given a textbook table of contents to analyze. The results were discouraging, i.e., the reliability was poor. Obviously, the texts were too difficult, the procedure was not specified well enough, and/or the students did not understand the categorization scheme.

After discussing the problems the students had in analyzing the text, some ground rules (numbers 1 and 2) and one pitfall (the first) were identified. In addition, the procedure was modified (see step #1). After incorporating these refinements into MACS, a group of six "analysts" were employed to analyze eleven community college textbooks/curriculum guides (herein termed "program descriptions) using the revised version of MACS. At the same time, the researchers met

with subject matter specialists for each program and reached consensus on a "standard" profile for each program (Appendix C). Each standard profile represented the unanimously agreed upon profile for each program. In order to reach such unanimity, each researcher (including a subject matter expert) first analyzed each program using the preliminary version of MACS noting any questionable categorizations. If there were any discrepancies in the results among the researchers, the researchers went through the analysis as a group, relationship by relationship. When there was disagreement, each researcher argued his position and either consensus was reached or, if that failed, more argument was solicited from each researcher. This process often involved reading parts of the textbook or curriculum guide in detail. Eventually this process yielded consensus on all eleven curricula. When this process was found to be difficult, additional ground rules were often generated which enabled the group to reach consensus. These additional ground rules have since been incorporated into MACS (numbers 3-9). Since the categorization scheme from which MACS is derived is presumed to be comprehensive for major types but not for sub-types, the focus of the validity testing and the development of standard profiles for each program description was on major types rather than on sub-types. Thus, discrepancies between totals on sub-types were ignored unless these discrepancies entailed discrepancies between totals for major types.

Validation of MACS

Validation of MACS implies determining whether or not MACS enables researchers to apply the categorization scheme objectively and moreover in a "correct" manner. The researchers were not testing

the validity of the categorization scheme itself, although the effective development of MACS would lend credence to the utility of the categorization scheme for analyzing programs.

The researchers investigated this problem of validity by attempting to answer the following question: What factors account for discrepancies between the sequencing profiles produced by a given analyst and the standard profiles produced by a group of "experts?"

Mean discrepancy ($\bar{D}$). In order to analyze discrepancies between analyst-produced profiles and expert-produced profiles, a mean discrepancy score was computed for each analyst-produced profile for each program description. This mean discrepancy ($\bar{D}$) score was computed by averaging discrepancies across sequencing principle types (T). For a given analyst (A) on a given program description (P) the mean discrepancy ($\bar{D}$) across T (types) was computed as follows:

$$\bar{D}_{.T.} = \left( 100 \sum_{T=1}^{5} \left| \frac{X_{.T.}}{\sum_{T=1}^{5} X_{.T.}} - \frac{S_{T.}}{\sum_{T=1}^{5} S_{T.}} \right| \right) \Big/ 5$$

where $X_{ATP}$ is the number of ordering relations analyst A categorized as sequencing principle type T when analyzing program description P and

where $S_{TP}$ is the number of ordering relations the team of experts (while generating a standard profile) categorized as sequencing principle type T when analyzing program description P.

Note that rather than use raw scores, the researchers adjusted each score by dividing it by the total number of relationships found. This adjustment was done so as not to interpret discrepancies between

total number of relationships found by analysts and by experts but, instead, to focus the data analysis on discrepancies between analyst- and expert-produced profiles.

As anticipated, the analysts agreed among themselves and with the "experts" on some programs and not on others. Tables 1 and 2 summarize $\bar{D}$ and S.D. for each program and for each analyst, respectively.

Table 1

| | Discrepancy | |
|---|---|---|
| Programs | Mean | S.D. |
| 1 | 5.53 | 12.98 |
| 2 | 23.67 | 22.04 |
| 3 | 17.50 | 13.87 |
| 4 | 10.75 | 9.69 |
| 5 | 14.65 | 8.68 |
| 6 | 19.00 | 4.16 |
| 7 | 26.78 | 10.62 |
| 8 | 6.85 | 7.63 |
| 9 | 0.00 | 0.00 |
| 10 | 27.00 | 17.14 |
| 11 | 3.70 | 9.07 |

Table 2

| | Discrepancy | |
|---|---|---|
| Analysts | Mean | S.D. |
| 1 | 11.96 | 12.61 |
| 2 | 9.06 | 11.45 |
| 3 | 16.51 | 16.64 |
| 4 | 12.37 | 9.63 |
| 5 | 20.34 | 13.33 |
| 6 | 9.29 | 10.22 |

Table 1 shows that some programs were more difficult to analyze than others (i.e., $\bar{D}$ ranged from 0.00 to 27.00). It might be useful to note that $\bar{D}$ had a maximum possible value of 40 and purely random numbers would have tended to result in a $\bar{D}$ of 20. Thus, the results indicate that depending on the program, analysts, as a group, ranged from analyzing perfectly to entirely missing the mark.

Furthermore, Table 2 shows that some analysts did a better job overall than others (ranging from a $\bar{D}$ of 9.06 to 20.34). What made a program difficult or easy to analyze and an analyst more or less competent are the questions the researchers thus pursued.

The initial question, regarding factors accounting for discrepancies, was sub-divided into the following two sub-questions: What characteristics of program descriptions best predict such discrepancies for a given analyst? What characteristics of analysts best predict discrepancies for a given program description?

After $\bar{D}$'s were computed for each analyst's profile of each program, they were correlated with other variables. These other variables were of three types: program variables, analyst variables, and analyst-program variables. In addition variables within each of the three types were intercorrelated.

Program variables. The program variables were as follows: "esotericness" of content, "explicitness" of content outline, complexity of profile, number of potential relationships, and number of relationships found (in standard).

"Esotericness" of content (ES) - mean score of all six analysts on Esoteric Content Rating (Appendix D).

"Explicitness" of content outline (EX) - mean score of all six analysts on Explicit Content Rating (Appendix D).

Complexity of Profile (COMP) - number of types of sequencing principles (from 1 to 5) on the "standard profile."

Number of Potential Relationships (NP)

$$\text{Number of Potential Relationships} = \frac{n^2 - n}{2}$$

Where n = the number of content elements in a given program

Number of Actual Relationships (NA) - the total number of scores on the standard summed across sequencing principle types or

$$\sum_{T=1}^{5} S_T.$$

Analyst variables. The primary analyst variable was the analyst understanding of the categorization scheme.

Understanding of Categorization Scheme (U) - score on the Sequence Categorization Test (Appendix E), a test constructed from the Posner-Strike scheme.

Analyst-Program variables. There were three variables that apply to a given analyst for a given program. These variables are in contrast to analyst variables which apply to a given analyst regardless of program and to program variables which apply to a given program regardless of analyst. These three analyst-program variables are labeled Familiarity with content, Confidence with analysis, and Time for analysis.

Familiarity with content (F) - a given analyst's score on Familiarity Rating (Appendix F) after analyzing a given program.

Confidence with analysis (CONF) - a given analyst's estimate of how confident he/she produced for a given program approximates the expert-produced profile. Operationally defined, CONF is a given analyst's score on Confidence Rating (Appendix F) for a given program's profile he or she produced.

Time for analysis (TIM) - Time spent by a given analyst doing an analysis of a given program. (Appendix F)

It should be noted that each analyst-program variable can be analyzed in two ways. First, one can interpret the variance of familiarity, confidence and time values for each analyst across programs. Second, one can interpret the variance of familiarity, confidence and time values for each program across analysts. In the first case these three variables are considered program variables (i.e., $F_P$, $CONF_P$, and $TIM_P$, respectively); in the second case they are considered analyst variables (i.e., $F_A$, $CONF_A$, and $TIM_A$, respectively); therefore, these three variables appear in analyses of both program and analyst variables.

Program variables as predictors of $\overline{D}$. The first data analysis consisted in attempting to predict $\overline{D}$ variance across programs. Program variables were correlated with $\overline{D}$ of each analyst across programs. Table 3 summarizes the mean correlation coefficients for these variables.

Table 3

Program Variables (n=11)

| | C | NP | NA | EX | ES | $F_P$ | $CONF_P$ | $TIM_P$ |
|---|---|---|---|---|---|---|---|---|
| Mean r | .54 | -.07 | -.02 | -.21 | .06 | -.29 | -.41 | -.23 |

Analyst variables as predictors of $\overline{D}$. The second data analysis consisted in attempting to predict $\overline{D}$ variance across analysts. In this case we were attempting to determine the relative predictive value of analyst characteristics whereas in the previous case we were attempting to determine the relative predictive value of program characteristics. Correlation coefficients were computed between analyst

characteristics and $\bar{D}$ across analysts for each program. Table 4 summarizes these mean correlation coefficients.

Table 4

Analyst Variables (n=6)

| | U | $F_A$ | $TIM_A$ | $CONF_A$ |
|---|---|---|---|---|
| mean r | .02 | -.01 | -.13 | .00 |

It should be noted that individual correlation coefficients were highly unstable due to the small number of cases (10 and 5 degrees of freedom, respectively). However, the mean correlation coefficients ($\bar{r}$) reported in Tables 3 and 4 are a good deal more stable, since these coefficients entail 54 (i.e., 66-12) and 44 (i.e., 66-22) degrees of freedom, respectively. Therefore, interpretation of correlation coefficients was limited to interpretation of $\bar{r}$'s.

## Conclusions

From an examination of Tables 3 and 4 it is clear that the best predictor of discrepancy is complexity of profile. That is, the more types of sequencing principles employed by a program, the more likely it is that analyst-produced profiles will deviate from the "standard." This finding is not surprising in itself. However, what is interesting about it is that this factor is a better predictor of discrepancy than any other. Tables 3 and 4 show that this factor (termed "complexity") is a far better predictor than a) the degree to which a given program's content is esoteric ($\bar{r}$ = .06), b) the degree to which a given program description's content outline is explicit ($\bar{r}$ = -.21), c) the number of potential ($\bar{r}$ = -.07) or actual ($\bar{r}$ = -.02) relationships in

a given content sequence, d) the familiarity of analysts with the concept in a given program ($\bar{r}$ = -.29), e) the confidence that an analyst has in his/her analysis ($\bar{r}$ = -.41), f) the time it took an analyst to complete a given analysis ($\bar{r}$ = -.23), or g) any analyst variable (Table 4).

Although analyst confidence ($CONF_P$) appears to be substantially correlated ($\bar{r}$ = 0.41) with mean discrepancy, an examination of Table 4 suggests that this coefficient might be spurious since the second analysis (i.e., $CONF_A$) produced a coefficient of zero. Needless to say, these ambiguous results are difficult to interpret. However, it is probably safe to say that they are a testament to the instability of correlation coefficients with few degrees of freedom. With this conclusion in mind, one should proceed to interpret any findings in this limited study with a great deal of caution.

The fact that understanding of the categorization scheme did not account for any $\bar{D}$ variance (r = .02) also presents interpretation problems. It is obvious to the researchers that one cannot misunderstand the categorization scheme and still use MACS in a valid manner. Since the reliability of the Sequence Categorization Test was substantial ($r_{odd\text{-}even}$ = .96; $r_{KR21}$ = .61), an interpretation of the weak relationship between scores on this test and $\bar{D}$ is warranted. The most plausible interpretation of the data is that the test, although reliable, failed to discriminate between competent and less competent analysts. A comment from one analyst expresses this idea most succintly: "The test wasn't as hard as analyzing a program description." Therefore, what needs to be developed is a test a) that results in a

broader range of scores and b) that possesses greater discrimination ability. Such a test would provide a useful device for determining when a potential analyst is ready to do an analysis.

Recommendations for Use of MACS

The major outcome projected for this study was a set of recommendations to users of MACS, based on empirical findings. Such recommendations are possible though must be considered tentative.

1. MACS is best used by a group of two or three analysts, each with an understanding of the Posner-Strike categorization scheme and of MACS itself. This group should include a subject matter specialist.

2. Group use of MACS is most needed when the program being analyzed is complex in terms of sequencing principles. The more major types of sequencing principles present in the program, the more group discussion is needed. Unfortunately, the complexity of a program is not known until after it has been analyzed. The following recommendations represent an attempt to cope with this problem.

3. A preliminary (though careful) analysis should first be done by someone knowledgeable about both the subject matter and the Posner-Strike scheme. If such a person is unavailable, then a person unfamiliar with the subject matter but knowledgeable about the Posner-Strike scheme (as evidenced by a high score on the Sequence Categorization Test) should be given the task of analyzing the program.

4. If the analyst a) produces a profile which reveals the presence of more than one major type of sequencing principle, or b) is not confident of his/her work (as measured by the Confidence Rating), then one or two other people should analyze the same pro-

gram and discuss any discrepancies between analyses until they reach consensus.

However, if the preliminary analysis results in a profile which reveals the presence of only one major type of sequencing principle and the analyst is confident in his/her analysis, then there is probably no need to consult additional analysts.

Implications

After further refinement and validation, MACS should prove useful for quantitatively describing any given program in terms of the type and extent of content sequencing relationships or "vertical structure."

However, even if one can assume that the five major types of content sequencing principles are comprehensive and conceptually distinct, they cannot fully describe the structure of any given program. In order to do this two distinct problems must be overcome. First, although a given program can only have one structure in any real sense, it may appear to have many distinct structures depending on the level of investigation or the operational definition of the content element that is selected. For example, a textbook's content sequence profile might be determined with MACS on the basis of "Parts," "Chapter Titles," "Chapter Sub-titles," "Paragraphs," "Sentences," or other potential definitions of content element. When using MACS, a specified content sequence profile pertains only to a defined level of content element.

Second, "structure" refers to all the relationships between the content elements, not just sequence principles or ordering relation-

ships. Thus, one would also want to identify the horizontal structure or "grouping relationships" if he wished to describe fully the structure of any given program. Although a method for analyzing content grouping principles might resemble MACS, such a method would need to be developed from a set of content grouping rather than sequencing concepts. These concepts would address the questions "In what ways can content elements be grouped and what is the rationale for grouping content in each way?" Once such a conceptual framework is described, it should be possible to develop a method for quantitatively identifying the type and extent of a program's "horizontal structure."

MACS as well as other methods for analyzing content structure should prove useful to evaluation and researchers interested in content sequence as a program variable. The five major types of sequencing principle represent fundamental and distinct ways in which content elements can be sequenced. These sequencing types and sub-types are useful conceptual tools for the evaluator interested in categorizing content sequencing principles and the method discussed in this paper provides a set of ground rules designed to make the categorization process more precise.

Researchers interested in investigating content sequence as a variable stand to benefit by using MACS and the categorization scheme from which it derives to design and/or describe more precisely their independent variables (i.e., content sequences). In addition, MACS may suggest a set of descriptive research questions (e.g., what kinds of sequencing principles do various types of curricula emphasize?).

A good deal of research is needed to determine the educational significance (if any) of content structure. How extensively should

a given program be structured? Which content sequence is better? Better how? Better under what conditions and for what audience? Unfortunately, we can presently only guess at the answers to these questions.

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Appendices

A. Categorization Scheme For Content Sequencing Principles

B. A Method For Analyzing Content Sequence (MACS)

B-1 Introduction
B-1 Pitfalls
B-3 Procedural Steps in Analyzing a Content Sequence
B-5 Ground Rules
B-11 Content Element-Sequencing Principle Matrix

C. Eleven Community College Programs

C-1 Program Descriptions
C-4 Standard Sequence Profiles

D. Program Variables

E. Sequence Categorization Test

F. Analyst-Program Variables

1.0 World-related. World-related sequences are those sequences in which there is consistency between the ordering of content, on the one hand, and relationships between phenomena as they exist or occur in the world on the other hand. That is, the content structure reflects empirical relationships between events, people, and things. An examplar of this type is the typical sequencing of history content based on the chronological sequence of events (i.e., the sub-type, Time).

1.1 Space. Sequences based on spatial relations are those in which the content elements are ordered in accord with the physical arrangement or position of the phenomena of interest. (Example: Teach the names of the states according to geographical location from east to west.)

1.2 Time. A temporal relationship between content elements reflects an antecedent-consequent order between events, or outcomes of events. Typically the content is sequenced chronologically from the earliest to the most recent events. (Example: Teach the names of the states in order of admission to the Union.)

1.3 Physical Attributes. World-related content sequences may be based on physical characteristics of the phenomena of interest such as size, age, shape, number of sides, brightness, hardness, physical complexity, etc. (Example: Teach the hardness scale for minerals from softest to hardest.)

2.0 Concept-related. While world-related sequences presumably reflect the organization of the empirical world, concept-related sequences reflect the organization of the conceptual world. That is, a sequence in which content (here, concepts) is structured in a manner consistent with the way the concepts themselves are related to one another (i.e., a priori relationships) is termed a concept-related sequence. A traditional curriculum embodying concept-related sequences is geometry when taught deductively (i.e., the sub-type termed Propositional Relations). More recently developed curriculum approaches placing a high priority on the organization of concepts include most of those curricula developed during the 1960's "curriculum reform movement" (e.g., BSCS biology, ESCP earth science, PSSC physics, CHEM Study chemistry). These curricula were described by the slogan "the structure of disciplines."

2.1 Class Relations. Sequences embodying this sub-type include the teaching about the general prior to teaching about its members, or investigating the properties of instances of a class before investigating the properties of the class. (Example: Teach about mammals before teaching about specific animals in that group.)

2.2 Propositional Relations. Common relations between propositions include entailment, reduction, contradiction, premise-conclusion, theory-evidence, and rule-example. Sequences of

Appendix A

## Categorization Scheme For Content Sequencing Principles[1]

The categorization scheme will suggest answers to the question "In what ways can content be sequenced?" thereby explicating the principles that can be used to sequence content.

In this scheme we refer to content elements. A content element, for the purpose of this analysis, is a proposition, concept, skill, or attitude, which is to be taught to pupils. Content sequences are part of the overall content organization or structure.

Most questions about content structure can be reduced to questions concerning what content comes before what other content and the rationale for that order, i.e., the sequencing principle.[2] Five major types of sequences have been identified and each major type has a number of sub-types.[3] The types and sub-types are as follows:

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[1]This description of the Posner-Strike categorization scheme for content sequencing principles should serve the reader only as a summary. The complete scheme is available from the Department of Education, c/o Prof. George J. Posner, 111 Stone Hall, Cornell University, Ithaca, New York 14853. It is not recommended that MACS be used without a thorough understanding of the scheme.

[2]Occasionally the problem of content structure is concerned with grouping principles rather than with sequencing principles. In these cases the important structural relationships hinge on the relation among content elements to be taught in conjunction, while order of the elements may be a matter of relative indifference. (See Posner, 1974, for an elaboration of the sequencing-grouping distinction.)

[3]The categorization scheme is presumed to be comprehensive for the major types but not for the sub-types. It should also be noted that the examples used to illustrate each sub-type were selected on the basis of their relative "purity," but not on the basis of their representativeness. Typical instances of actual content sequences are blends of several of the sub-types and even several of the major types.

this sort include teaching evidence prior to the proposition which the evidence supports, teaching a theory prior to the facts which the theory explains, and teaching micro-laws before teaching macro-laws. (Example: Teach the principle of "equal protection under law" before studying the 1954 Supreme Court decision on Civil Rights.)

2.3 Sophistication. Concepts and propositions can differ in their level of precision ("acceleration" is less precise than "v/t"), conceptual complexity (the number of concepts subsumed by a concept), abstractness (the distance from particular things or facts; usually the opposite of concrete), vagueness (the extent to which a concept bears a "family resemblance" to other concepts; usually the opposite of clarity), range (the number of instances to which a concept refers) and level of refinement (adding qualifications to a concept or proposition refines it). Sophistication embodies all of these aspects and the above list is intended to be representative rather than exhaustive. (Example: Teach what "acceleration" means before teaching it as "v/t".)

2.4 Logical Prerequisite. A concept or proposition is a logical prerequisite of another concept or proposition when it is logically necessary to understand the first concept or proposition in order to understand the second. (Example: Teach what "velocity" means before teaching that "acceleration" is the change in velocity.)

3.0 Inquiry-related. Inquiry-related sequences are those which derive from the nature of the process of generating, discovering or verifying knowledge. Therefore, such sequences reflect the nature of the logic or methodology of a given area of thought. Dewey's attempt to structure teaching according to his analysis of the scientific method is a notable example of an Inquiry-related approach to sequence.

3.1 Logic of Inquiry. Sequencing principles rooted in logic will reflect views of valid inference. (Example: Discover ways to light a bulb with a battery, then generalize a rule.)

3.2 Empirics of Inquiry. Some features of proper inquiry are rooted in descriptions of how successful scientists actually proceed or in the social or psychological conditions of fruitful inquiry. (Example: Teach what other researchers have discovered about reinforcement schedules before teaching pupils to frame hypotheses about optimal reinforcement schedules.)

4.0 Learning-related. Learning-related content sequences draw primarily on knowledge about the psychology of learning. Exemplar sequences of this type can be found in AAAS' Science - A Process Approach which employs the sub-type termed Empirical Prerequisite (in addition to the Logical Prerequisite sub-type).

4.1 Empirical Prerequisite. If it is found that the learning of one skill facilitates or makes possible the learning of a subsequent skill, the first skill can be termed an empirical prerequisite of the second. Empirical Prerequisite contrasts with Logical Prerequisite (sub-type 2.4) in that the latter is concerned with relations based on properties of concepts (i.e., a priori) and the former is concerned with empirically based relations (typically between skills) regardless of their logical necessity. Naturally, what is logically necessary usually turns out to be empirically verifyable but the converse does not hold. (Example: Teach alphabetizing words before dictionary skills.)

4.2 Familiarity. An individual's past experiences are often the basis of sequencing. Familiarity refers to the frequency with which an individual has encountered an idea, object or event, i.e., how commonplace it is to the individual. Sequences of this sub-type order elements from the most familiar to the most remote. (Example: Teach about American schools before teaching about Swedish schools.)

4.3 Difficulty. Factors affecting difficulty as conceived here include a) how fine a discrimination is required, b) how fast a procedure must be carried out and c) the mental capacity required for learning (e.g., memorizing five names is typically more difficult than memorizing two names). Sequences of this sub-type would teach the less difficult before the more difficult content. (Example: Teach long vowel sounds before short ones.)

4.4 Interest. Content elements that are intrinsically interesting are commonly those that refer to phenomena about which the learner has had some limited experience (i.e., not totally unknown to him) but remain a challenge, retain the potential for surprise, or can arouse curiosity. (Example: Teach pupils how to pick a lock before teaching them how a lock works.)

4.5 Development. Developmental psychologists such as Kohlberg and Piaget contend that content is best learned when the learner is developmentally "ready" to learn it. That is, "the ideal order of studies is one in which each experience is introduced at the most propitious time in the person's development" (Phenix, 1964, p. 291). (Example: Teach the pupils about set theory first at the concrete operations level, then at the formal operations level.)

5.0 Utilization-related. Content can be sequenced a) in a way that reflects procedures for solving problems or fulfilling responsibilities, or b) according to the utilization potential of a given content element.

5.1 Procedure. In programs when we are teaching a procedure or process and the content elements represent steps in the process, it is often appropriate for the sequence to reflect the order in which the steps will be followed when carrying out the procedure. (Example: Teach proper golf grip before teaching address of the ball.)

5.2 Anticipated Frequency of Utilization. Often we teach the most important content first and by "most important" we mean that which the pupil is likely to encounter most often. That is, we predict the likelihood of encounters the pupil will have with various phenomena and we order the phenomena about which we teach based on the anticipated frequency of utilization in the pupil's future experiences. (Example: Teach the use of chi-square test before the Mann-Whitney U test.)

In summary, content can be sequenced according to five different bases: a) a world-related basis (i.e., based on empirically discoverable relations between people, things or events), b) a concept-related basis (i.e., based on relations among concepts), c) an inquiry-related basis (i.e., based on the process by which knowledge and concepts are produced), d) a learning theory-related basis (i.e., based on the psychology of learning), and e) a utilization-related basis (i.e., based on the way things are used after they are learned).[4] The world-, concept- and inquiry-related bases for sequences are concerned with the subject matter and the way that subject matter comes to be. On the other hand, the learning theory- and utilization-related bases are reliant or human purposes and psychologies and are more concerned with economy of learning for the individual learner.

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[4] Of course, many decisions regarding the sequencing of content are not based on any of these five types of ordering relations but, instead, on factors relating to implementation of the program in a specific situation. Such factors as materials and facilities available, time schedules, weather and climate, location of the school, transportation needs, and teachers' interests or competencies are likely to be powerful determinants of sequencing. These factors have been referred to as "frame factors" (Dallof, 1970). Such factors may be considered a sixth type, termed implementation-related.

Appendix B

A Method for Analyzing Content Sequence ©

(MACS)

Introduction:

The method you are about to use consists of a "content element-sequencing principle" matrix, pitfalls, recommended procedural steps, and ground rules. These items (the matrix, pitfalls, procedures and ground rules) make up the Method for Analyzing Content Sequence (MACS). It is essential to master each of the above components for reliable results in using the MACS.

Pitfalls:

There is a tendency to pre-determine sequencing principles on the basis of the nature of the subject matter. For example, educational materials in vocational subjects are often thought about in terms ofutilization while the academic disciplines like biology, chemistry, etc. are thought about primarily in terms of concepts.

Often this tendency stems from a confusion between the processes of content selection and sequencing. Principles or criteria of content selection are found by asking the question, "why these content elements?" In contrast to selection, sequencing principles or criteria are found by asking the question, "why in this order?" Content elements may be selected for one reason but ordered in a particular way for an entirely different reason. For instance, a

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general overview of the ignition system might be taught before teaching about each of that system's component parts (e.g., the starter). These elements have been selected on the basis of their utilization in the servicing of cars. That is, the question "why these elements?" is answered by describing their importance in fixing cars. However, they have been ordered on a concept-related basis. That is, the question "why in this order?" is answered in the following way: the overview describes the major concept, i.e., the ignition system, whereas the component parts of that system are concepts subsumed by that system. Thus, failure to distinguish selection from sequencing criteria can be a major source of error in applying the Method.

Another pitfall is the tendency to confuse sequencing with grouping principles. Grouping principles refer to the rationale for teaching elements in conjunction. Sequencing principles refer to the rationale for teaching one element after another. Sequencing and grouping principles can be different for a given sequence of content elements. For example, we may teach about psychological, sociological, and philosophical determinants of education because they are all factors influencing education (i.e., the rationale for grouping), but we may teach them in any order if there is no rationale for any particular order (i.e., there is no sequencing principle). MACS is concerned only with sequencing principles (i.e., ordering relations).

Procedural Steps in Analyzing a Content Sequence:

The "content elements-sequencing principles" matrix is simply a way of displaying each of the content elements in a textbook or curriculum guide and indicating its relation to each of the other content elements. The matrix has content elements along the vertical dimension and sequencing principles along the horizontal dimension.

Step 1: List the chapter titles (or categories of content elements in a curriculum guide) on the content-element column, starting with the last chapter first. Each chapter will thus occupy one row of the matrix.

E.g., Chapters

5
4
3
2
1

Often textbooks are organized at more than one level. Typically "chapters" are organized into "parts" so that each "part" contains two or more "chapters." The organization of "chapters" within any "part" is termed a "micro-level" organization and the organization among "parts" is termed a "macro-level" organization. The important point to understand is that there can be more than one level of content sequence analysis. Whether the micro-level represents "chapters" within one "part" or "modules" within one "unit," this level is distinct from a more macro-level.

In the present procedure the analyst should do as many complete micro-level analyses as there are micro-level organizations. For example, if a textbook has five "parts" with four chapters in

each part, the analyst should do five separate micro-level analyses (i.e., one for each "part") but only one macro-level analysis (i.e., describing the organization among parts).

Step 2: Examine the specific relationship between the last and second to last chapter. You can do this either by deciding first on the major type of sequencing principle, then the sub-type within that major type, or by determining the sub-type and then the major type. In either case, when you decide on the sub-type, score (i.e., check) the appropriate cell in the last chapter's row. If you determine that the sequencing principle is of a particular type but you cannot find an appropriate sub-type, score "other" under the chosen major type. Remember the categorization scheme is presumed to be comprehensive for major types but not for sub-types. If there is no apparent relationship between chapters, do not score anything.

In order to determine if an ordering relationship does or does not exist between content element A and content element B, pointed questions are useful. Ask the following question: Is there a rationale for A following B? If "Yes," then you need only find that rationale (i.e., sequencing principle) even if by the process of elimination. Other questions which help in this analysis are as follows: Would the rationale for B following A be the same or different from the rationale for A following B? Some sub-types imply directionality and some do not. For example, whether we order elements from largest to smallest or smallest to largest, the appropriate sub-type is still 1.3 (Physical Attributes). However, for 2.4 (Logical Prerequisite) the prerequisite concept or

proposition must be taught first or the relationship is not 2.4. On the other hand, maybe there is no rationale. That is, could the decision to teach A following B or B following A have been made by a flip of a coin or is there some rationale for the decision? If such is the case, score nothing.

Step 3: Now examine the relationship between the content element and the third from the last chapter. After determining the sub-type, again score the appropriate cell in the last content element's row. Repeat this procedure for each of the content elements.

Step 4: Now start with the second to last content element and work toward the earlier content elements one by one in a manner similar to that described in steps 2 and 3. Repeat this procedure for each content element until the relationship between all pairs of content elements have been examined.

Step 5: At the end of the analysis, add the score for all the sub-types within each major type. What you will now have is the total number of ordering relations for each major type. These totals comprise the textbook's or curriculum guide's "profile."

Ground Rules:

1. Always work from the last content elements to the first chapters. Never work back and forth.

E.g., Chapters

5
4
3
2
1

Examine content elements in the following order: 5 with 4; 5 with 3; 5 with 2; 5 with 1; 4 with 3; 4 with 2; 4 with 1; 3 with 2; 3 with 1; and 2 with 1.

This ground rule will insure that no ordering relation between two given content elements will be counted more than once.

e.g., if chapter 6 is related to chapter 5 on the basis of Familiarity, do not score it for any other sub-type.

2. If a pair of content elements are related to each other on one basis (e.g., Empirical Prerequisite) by virtue of their being related on another basis (e.g., Logical Prerequisite) score the latter rather than the former sub-type. You can think of the above as being a case of one category dominating another. For instance, any Inquiry-related ordering is also Utilization-related, since Inquiry is a process utilized by researchers. Therefore, a pair of chapters could be utilization-related by virtue for their being Inquiry-related. In this case Inquiry-related would get the score.

The following chart lists common instances when categorical dominance occurs and indicates the way to score such cases.

Table 1 Common Instances of Categorical Dominance and How To Score Them

| If the ordering relation is | Because it is also | Score the ordering relation |
|---|---|---|
| Logic of Inquiry (3.1) | Propositional Relations (2.2) | Propositional Relations (2.2) |
| Empirical Prerequisite (4.1) | Class Relations (2.1) | Class Relations (2.1) |
| | Difficulty (4.3) | Difficulty (4.3) |
| | Sophistication (2.3) | Sophistication (2.3) |
| | Logical Prerequisite (2.4) | Logical Prerequisite (2.4) |
| Difficulty (4.3) | Empirical Prerequisite (4.1) | Empirical Prerequisite (4.1) |
| | Familiarity (4.2) | Familiarity (4.2) |
| | Interest (4.4) | Interest (4.4) |
| | Internalization (4.5) | Internalization (4.5) |
| | Sophistication (2.3) | Sophistication (2.3) |
| Interest (4.4) | Familiarity (4.2) | Familiarity (4.2) |
| | Empirical Prerequisite (4.1) | Empirical Prerequisite (4.1) |
| | Logical Prerequisite (2.4) | Logical Prerequisite (2.4) |

3. Application of Ground Rule 2 will help you choose between sub-types when more than one sub-type seems plausible. There will be times when you still are unable to limit yourself to only one sub-type. However, still check only one sub-class for each pair or chapters considered. Try to decide which sub-type is the most appropriate. Occasionally you will feel that you are being somewhat arbitrary. But if you have considered "categorical dominance" (i.e., ground rule 2) and have considered whether one of the possible sub-types is most appropriate, then this arbitrariness will be kept to a minimum. Hopefully, the number of instances when you must be entirely arbitrary will be few.

4. When the choice is between no relationship and some relationship, even though the relationship is a weak one, score the category most appropriate.

5. When content elements are at a macro-level (i.e., when there are many micro-level content elements subsumed by the element in question), it may be difficult to decide on which aspect of the macro-level element the categorization decision should be based. This problem arises especially when the macro-level element is conjunctive (e.g., "Galaxies and Cosmology"). In cases such as these, examine the textbook/curriculum guide, try to determine which aspect is the dominant one, and score the ordering relations on the basis of the dominant aspect.

However, in no case, score more than one ordering relation for any given pair of content elements. If this problem appears particularly troublesome, you may decide that an analysis at this

macro-level is too arbitrary and chose not to carry it out. Instead, you may decide to break up conjunctive elements into their components before analyzing their sequence. If you decide on this procedure, make certain that other analysts do the same.

Similarly, you may want to group several content elements into one, treating this group as a single element (e.g., "Organic Compounds I" and "Organic Compounds II" can be grouped into "Organic Compounds"). The important thing for reliability is that all analysts are operating on the same set of content elements.

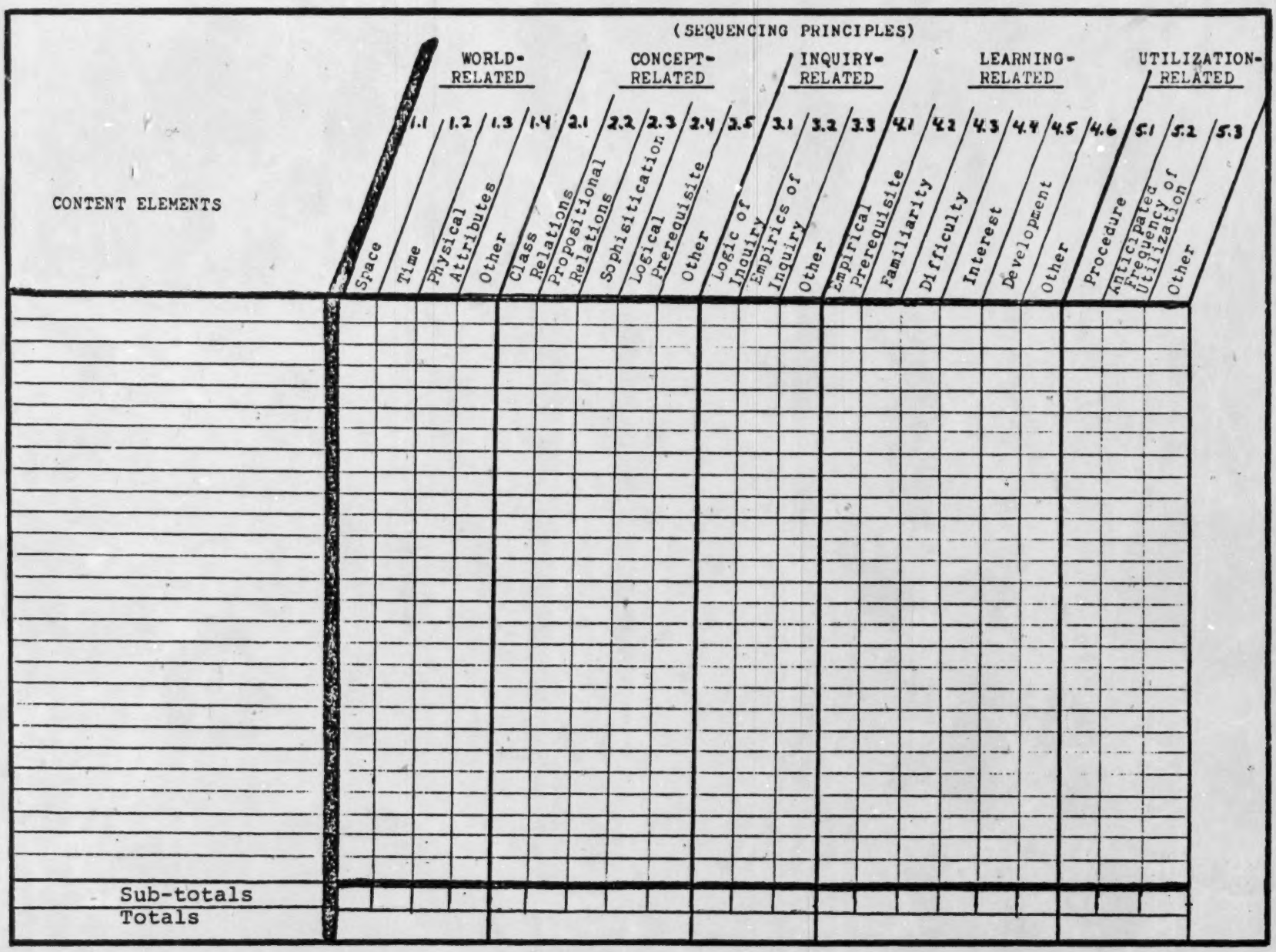
6. Do not attempt to read into the content elements the author's intent. Instead, take content at face value. Determine the ordering relation appropriate for the particular pairs of content elements, even though the author may not have had any rationale for ordering them in that particular way or even though he/she may have had a different sequencing principle in mind. Do not attempt to read the author's mind.

7. Knowledge about the audience to whom the textbook/curriculum guide is addressed is necessary for categorizing Learning- and Utilization-related sequencing principles. For example, what is familiar for one group of students may be unfamiliar for another group. Determining the actual situation(s) in which the textbook/curriculum guide is to be used is the most valid approach.

8. In order to distinguish between 5.1 (Procedure) and 4.1 (Empirical Prerequisite) the following rule of thumb may be helpful: If it is a case of what activity you must <u>do</u> first, then classify it as 5.1. If it is a case of what skill you must <u>learn</u> first, classify it as 4.1. For example, in landscaping you must

analyze the site before you can choose construction materials. But you need not learn how to analyze the site first. If someone were to give you a completed site analysis, you could then proceed to choose materials. Therefore, the ordering reflects procedural steps, not prerequisite learnings.

9. In order to distinguish 3.0 (Inquiry-related) from 2.0 (Concept-related) the following rule of thumb may be helpful: If the emphasis is on the process of inquiry, then score an Inquiry-related sub-type. If the emphasis is on the products of inquiry, then score a Concept-related sub-type. For example, if hypotheses are taught before evidence, the emphasis is on the products of hypothesis formation and evidence gathering; therefore, score 2.2 (Propositional Relations). On the other hand, if the content emphasizes the process of forming hypotheses and the process of gathering evidence, then score 3.1 (Logic of Inquiry). Obviously the categorization decision becomes more arbitrary when process and product are mixed (e.g., hypotheses and evidence gathering). In such cases, you should attempt to determine primary emphasis.




Content Element-Sequencing Principle Matrix

## Appendix C

## Eleven Community College Program Descriptions

1. Abel, J., Glossner, C., and Hoover, D. Structures of Mathematics. Corning, NY: Corning Community College Press, 1974.

| | |
|---|---|
| Unit I | Counting |
| Unit II | Intro. to Sets & Venn Diagrams |
| Unit III | Operations on Sets & Venn Diagrams |
| Unit IV | Egyptian, Ionic-Greek & Roman Systems (simple grouping for base 5) |
| Unit V | Chinese-Japanese, Babylonian, Mayan, Hindu-Arabic Systems (base 5, mult. grouping, positional) |
| Unit VI | Base Systems (incl. fractions) |
| Unit VII | Operations in Base Systems |
| Unit VIII | Naturals, Wholes, Integers |
| Unit IX | Rationals, Irrationals |
| Unit X | Reals, Complex |
| Unit XI | Metric System - Intro. & Linear Conversion |
| Unit XII | Metric System - Mass, Vol., Temp., Conversion |

2. Kenner, W. Machine Tools. Corning, NY: Corning Community College Press, 1973.

| | |
|---|---|
| Week 1 | General Safety Rules |
| Week 2 | Measuring and Gauging Unit |
| Week 3 | Bench Work - Layout and Small Hand Tools |
| Week 4 | Drill Press |
| Week 5 | Twist Drill and Drilling |
| Week 6 | Single Point Cutting Tools |
| Week 7 | Elementary Engine Lathe - Part I |
| Week 8 | Elementary Engine Lathe - Part II |
| Week 9 | Milling Machines and Index Head |
| Week 10 | Milling Cutters |
| Week 11 | Thread Cutting |
| Week 12 | Shaper |
| Week 13 | Grinding Wheels and Machines |
| Week 14 | Secondary Cutting Operations |

3. Rice, L. A., Boyd, A. C. and Mayne, F. B. Business Mathematics for Colleges (5th ed). Chicago: South Western Publishing Co., 1966.

| | |
|---|---|
| Part I | Fundamental Mathematical Processes |
| Part II | Fractions: Decimal and Common |
| Part III | Percentage in Business |
| Part IV | Interest |
| Part V | Compound Interest |
| Part VI | Payrolls and Taxes |
| Part VII | Financial Statements |
| Part VIII | Special Problems |

4. Hyman, L. H. Comparative Vertebrate Anatomy. Chicago: University of Chicago Press, 1960.

| | |
|---|---|
| I | General Considerations on Animal Form |
| II | The Phylum Chordata |
| III | Essential Features of Lower Types |
| IV | External Anatomy and Adaptive Radiation in Gnathostomes |
| V | General Features of Chordate Development |

VI The Comparative Anatomy of the Skin and the Exoskeleton
VII The Endoskeleton: The Comparative Anatomy of the Vertebral Column and Ribs
VIII The Endoskeleton: The Comparative Anatomy of the Girdles, the Sternum, and the Paired Appendages
IX The Endoskeleton: The Comparative Anatomy of the Skull and the Visceral Skeleton
X The Comparative Anatomy of the Muscular System
XI The Comparative Anatomy of the Coelom and of the Digestive and Respiratory Systems
XII The Comparative Anatomy of the Circulatory System
XIII The Comparative Anatomy of the Urogenital System
XIV The Comparative Anatomy of the Nervous System and the Sense Organs

5. Nelson, W. R. Landscaping Your Home. Urbana, Ill.: University of Illinois, 1963.

1. Your Landscape Needs
2. Starting Your Plan
3. Analyzing the Site
4. Choosing Landscape Structures
5. Choosing Construction Materials
6. Fitting Plants to Your Environment and Design
7. Fitting Trees to Your Plan
8. Fitting Shrubs to Your Plan
9. Fitting Flowers to Your Plan
10. Designing the Public Area
11. Designing the Living Area
12. Buying and Planting Plants
13. Taking Care of Your Plants
14. Selected List of Plant Materials

6. Foster, R. J. and Gong, W. A. (eds.) Astronomy. Columbus, Ohio, 1966.

1. The Beginnings of Astonomy
2. The Earth and the Moon
3. The Tools and Methods of the Astronomer
4. Planets and Satellites; Comets and Meteors
5. The Sun. An Introduction to the Stars
6. Variety Among Stars
7. Galaxies and Cosmology

7. Kepler, F. Automotive Technology. Corning, NY: Corning Community College Press, 1974.

I Introduction to Automotive Technology
II Internal Combustion Engine
III Auto Shop I - Trouble Shooting, Inspection, and Servicing
IV Auto Shop II - Tune-ups and Minor Reparis
V Chasis
VI Auto Specialized - Business Operation
VII Auto Shop III
VIII Auto Shop IV

8. Kinch, J. W. Social Psychology. N.Y.: McGraw-Hill, 1973.

1. Introduction

2. Sources of Evidence
3. Society and the Individual
4. Communication, Language, and Perception
5. Interaction Processes: Role-Taking and the Self-Concept
6. Variations in the Human Group
7. Similarity in Groups
8. Socialization
9. Collective Behavior and Mass Communication
10. The Social Psychology of Deviance
11. Social Change

9. Baldwin, L. D. The Stream of American History (4th ed). N.Y.: Van Nostrand Reinhold, 1969.

| | |
|---|---|
| Prologue | The Roots of the American Way |
| Part 1 | The Genesis of the Nation |
| Part 2 | The New Nation |
| Part 3 | The Testing of the Nation |

10. Brown, J. (ed.) Integrated Science. Corning, NY: Corning Community College Press, 1974.

| | |
|---|---|
| Unit I | Man and His Physical World |
| Unit II | The Chemical Organization of Life |
| Unit III | The Cell - Fundamental Unit of Life |
| Unit IV | Human Organization |
| Unit V | Man's Endeavors Toward Better Health |

11. Lambert, B. G., Rothschild, B. F., Altland, R., and Green, L. B. Adolescence. Monterey, Calif.: Broods/Cole, 1972.

| | |
|---|---|
| Part I | Introduction to Adolescence |
| Part II | Environmental Factors in Adolescent Development |
| Part III | Physical and Sexual Development in Adolescents |
| Part IV | Normal and Deviant Adolescent Emotional Development |
| Part V | Problems Unique to Adolescent Development |

Standard Sequence Profiles of Eleven Community College Programs

| PROGRAMS | Standard Sequence Profile Type 1 | 2 | 3 | 4 | 5 | Number of Relationships Found | Potential Number of Relationships | Percent Vertical Structure Extensiveness |
|---|---|---|---|---|---|---|---|---|
| 1. Structures of Mathematics | 0 | 31 | 0 | 0 | 0 | 31 | 66 | 45 |
| 2. Machine Tools | 0 | 0 | 0 | 26 | 48 | 74 | 91 | 81 |
| 3. Business Mathematics for Colleges | 0 | 20 | 0 | 0 | 7 | 27 | 28 | 96 |
| 4. Comparative Vertebrate Anatomy | 19 | 34 | 0 | 0 | 0 | 53 | 91 | 58 |
| 5. Landscaping Your Home | 0 | 34 | 0 | 0 | 44 | 78 | 91 | 86 |
| 6. Astronomy | 11 | 5 | 0 | 5 | 0 | 21 | 21 | 100 |
| 7. Automotive Technology | 4 | 10 | 0 | 1 | 2 | 17 | 28 | 61 |
| 8. Social Psychology | 0 | 49 | 0 | 0 | 0 | 49 | 55 | 89 |
| 9. The Stream of American History | 6 | 0 | 0 | 0 | 0 | 6 | 6 | 100 |
| 10. Integrated Science | 0 | 10 | 0 | 0 | 0 | 10 | 10 | 100 |
| 11. Adolescence | 0 | 10 | 0 | 0 | 0 | 10 | 10 | 100 |

Appendix D

Program Variables

Explicit Content Rating. How explicit, elaborated or detailed is the table of contents or content outline? (How well can you discern the the nature of the content from the table of contents?)

5. highly detailed (specific content is identified and the nature of the content is clear. No need to refer to text.)

4. moderately detailed (seldom need to refer to text)

3. barely detailed enough

2. insufficient detail (Must frequently refer to text)

1. no detail at all (not able to make reasonable judgments regarding content sequencing principles from table of contents)

Esoteric Content Rating. Esoteric means "understood by or meant for only the select few who have special knowledge or interest." How esoteric (not necessarily difficult) is the content and in particular the terminology?

5. highly esoteric (only a specialist in this area (0-5% of population) would know what the terminology means)

4. somewhat esoteric (a small portion (5-15%) of our adult population would know what the terminology means)

3. fairly common (some of our adult population (15-50%) would know what the terminology means)

2. very common (a majority of our adult population (50-90%) would know what the terminology means)

1. widely known (anybody (90-100%) over the age of 12 would know what the terminology means)

Appendix E

## Sequence Categorization Test

1. Teach pupils to respect others' property then to respect others' feelings.

4.5 1.3, 2.2, 4.5, 5.2

2. Teach about propaganda then examine the influences affecting our consumer habits.

2.2 1.2, 2.2, 4.1, 5.2

3. Teach the governmental structure of monarchies then the governmental structure of republics.

2.3 1.3, 2.3, 4.3, 5.2

4. Teach reinforcement theory before teaching about the extinction of behaviors

2.4 2.4, 3.2, 4.2, 5.2

5. Teach how to breathe properly in water then teach the strokes of swimming.

4.1 1.3, 2.4, 4.1, 5.2

6. Have pupils observe a pond from a blind then try to determine the food chains of that pond.

3.1 1.3, 2.3, 3.1, 5.1

7. Teach pupils to construct a sundial before teaching planetary motion.

4.4 1.1, 2.3, 3.2, 4.4

8. Teach about the colonization of North America before teaching about westward expansion.

1.2 1.2, 2.1, 3.1, 4.2

9. Teach proper use of a hammer before use of a turret lathe.

5.2 1.3, 2.3, 3.1, 5.2

10. Teach students to select the proper ornamental tree for specific conditions, then how to plant it, then how to care for it.

5.1 1.2, 2.3, 4.1, 5.1

11. Teach about bartering before teaching about monetary systems.

2.3 1.3, 2.3, 4.4, 5.3

12. Teach the names of local trees, then trees not found in the locality.

4.2 1.2, 2.2, 4.2, 5.3

13. Teach the concept of friction then teach how tire and road conditions affect the driving of a car.

2.2 1.3, 2.2, 3.1, 5.2

14. Teach driving in a parking lot before on the highway.

4.3 2.4, 3.1, 4.3, 5.2

15. Teach the biomes of the continental United States from East to West Coast.

1.1 1.1, 2.2, 4.2, 5.2

16. Teach the elements in order of their atomic weight.

1.3 1.3, 2.1, 3.2, 5.1

17. Teach pupils to write an advertisement for a product before teaching propaganda.

4.4 2.3, 3.1, 4.4, 5.1

18. Teach about neurosis then teach some of the numerous neurotic manifestations.

2.1 1.3, 2.1, 3.1, 4.1

19. Teach patriarchal family structure before matriarchal family structure.

4.2 1.1, 2.1, 3.2, 4.2

20. Teach pupils how to treat minor injuries before teaching artificial respiration.

5.2 1.3, 2.4, 3.1, 5.2

21. Teach modes of transportation from slowest to fastest.

1.3 1.3, 2.3, 4.3, 5.2

22. Teach 18th century literature then modern literature.

1.2 1.2, 2.3, 4.1, 5.1

23. Teach solar system from the Sun to Pluto.

1.1 1.1, 2.4, 3.1, 4.2

24. Teach the rules of addition before teaching multiplication as repetitive addition.

2.4 1.4, 2.4, 4.4, 5.2

25. Teach how to discover facts about the past then teach conclusions about the past.

3.1 1.2, 2.3, 3.1, 4.3

26. Teach how to solve linear equations before solving quadratic equations.

4.1 1.3, 3.2, 4.1, 5.2

27. Teach that industrial nations will soon be at the mercy of underdeveloped nations possessing natural resources before concluding that the world living standard between nations will tend to equalize.

2.2 1.3, 2.2, 4.3, 5.2

28. Define taxation before examining the assessment of property taxes.

2.1 1.1, 2.1, 4.4, 5.1

29. Teach about the concept of dimensionality before teaching about measurement.

2.4 1.1, 2.4, 4.3, 5.2

30. Teach students the shape, size, weight, and density of objects that float then have the students generalize a rule about floating objects.

3.1 2.1, 3.1, 4.1, 5.1

Appendix F

Analyst-Program Variables

Familiarity Rating. How familiar are you with the specific subject matter?

5. expert (could teach subject)

4. very familiar

3. familiar

2. not very familiar

1. unfamiliar (should disqualify myself as evaluator)

Confidence Rating. To what degree do you feel you have correctly identified the exhisting content sequencing principles?

5. extremely confident (would expect to agree with expert on 80-100% of relationships)

4. very confident (would expect to agree with expert on 60-80% of relationships)

3. reasonably confident (would expect to agree with expert on 40-60% of relationships)

2. not very confident (chance I might agree with expert on 20-40% of relationships)

1. unsure (would tend to discount my results)

Analysis Time. How much time did you spend identifying the existing content sequencing relationships? (Do not count time taken to set up forms or time spent on non-related activities. Your total time on the overall project will of course be greater than the sum of your analysis times.)